

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT I, MASAMI MIYAJIMA, a  
citizen of Japan residing at Kanagawa, Japan have  
invented certain new and useful improvements in

DIGITAL IMAGE READING APPARATUS

of which the following is a specification:-

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to digital image reading apparatuses such as digital copying machines or image scanners, and more particularly to a digital image reading apparatus including a stepping motor.

2. Description of the Related Art

In a conventional digital image reading apparatus reading a document image and transferring the image data to an external apparatus such as a host computer via an interface such as small computer system interface (SCSI), a document reading rate is determined to be a unique value by preset reading density. A rate of transferring the image data to the external apparatus receiving the image data (hereinafter referred to an image data transfer rate) is fixed by a data processing rate of the external apparatus. Therefore, in the case of transferring a certain amount of image data determined by reading density and a reading area from the digital image reading apparatus to the external apparatus, the image data is transferred to the external apparatus without a delay if the image data transfer rate is

higher than the document reading rate. However, if the image data transfer rate is lower than the document reading rate, the image data is temporarily stored in memory housed in the digital image reading apparatus, and the stored image data is transferred in accordance with the image data transfer rate.

In general, the transfer of image data from the digital image reading apparatus to the external apparatus is performed in the following procedure.

10 In step 1, image data read by a reading unit is stored in image memory of a DRAM. In step 2, the image data is transferred from the image memory of the DRAM to the external apparatus. The steps 1 and 2 are performed in parallel. However, there is a

15 difference between a rate of storing the image data into the image memory (hereinafter referred to as an image data storing rate) and the image data transfer rate. Therefore, the image data is gradually accumulated in the image memory if the image data

20 transfer rate is low or the reading of the image data is performed with high density. Since the storage capacity of the image memory is limited, the reading of the image data should be suspended at a certain point.

25 As a scanning system motor or a document

conveying system motor of the digital image reading apparatus, a stepping motor is frequently employed. In controlling the stepping motor, a speed control operation of gradually decreasing the speed of the stepping motor is performed since the stepping motor is characteristically prevented from making an instant stop. At a point when room is generated in the storage capacity of the image memory as the image data is transferred to the external apparatus after the suspension, the stepping motor is driven again by canceling the suspension so that the reading operation is resumed. In resuming the reading operation, a speed control operation of gradually increasing the speed of the stepping motor is performed since the stepping motor is characteristically prevented from being driven instantly.

However, if the image data storing rate is relatively higher than the image data transfer rate, the above-describe speed control operations are sometimes repeated a number of times in a single reading operation. Obviously, a better image quality can be obtained by a reading operation at a constant rate than by a reading operation including the above-described speed control operations. Therefore,

5 frequent occurrence of such a situation may  
deteriorate the image quality (quality of the read  
image) to a considerable extent. Indeed, an increase  
in the storage capacity of the image memory can lower  
the occurrence frequency of the above-described speed  
control operations, but at the same time, incurs  
rising costs.

10 Therefore, in a reading operation expecting  
a large data transfer amount of image data, such as a  
color or multivalued reading operation, a reading rate  
is preset to be lower than that of a binary reading  
operation so that the data transfer amount becomes  
equal to or approaches a read data amount.

15 However, in the reading operation expecting  
a large data transfer amount of image data, such as a  
color or multivalued reading operation, the reading  
rate is preset to be lower than that of the binary  
reading operation irrespective of the total image  
data amount of read image. Therefore, a reading time  
20 becomes longer, thus lowering the performance of the  
apparatus.

#### SUMMARY OF THE INVENTION

25 It is a general object of the present  
invention to provide a digital image reading

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apparatus in which the above-described disadvantages are eliminated.

5 A more specific object of the present invention is to provide a digital image reading apparatus that allows a minuter setting of a vertical scanning reading rate based on a total image data amount of a read image and also allows a reading time to be shorter to increase its performance even in the case of a color or multivalued reading operation  
10 expecting a large data transfer amount.

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The above objects of the present invention are achieved by a digital image reading apparatus including a reading part for optically reading an image of a document to output digital image data, a  
15 first setting part for setting a reading rate in a given scanning direction to a desired value, an image memory for temporarily storing the image data, a second setting part for setting parameters related to reading the image of the document based on  
20 communication with an external apparatus, and a computation part for computing a total amount of the image data from the parameters, wherein the first setting part sets the reading rate based on the total amount of the image data.

25 The above objects of the present invention

are also achieved by a digital image reading apparatus including an optical reader optically reading an image of a document to output digital image data, a memory temporarily storing the image data from the optical reader, and a controller computing a total amount of the image data of the document and controlling a reading rate in a given scanning direction on the basis of the total amount of the image data stored in the memory.

10 According to the above-described apparatuses, the reading rate in the vertical scanning direction is set based on the total amount of the image data computed based on the parameters related to reading the image of the document. Therefore, the reading rate in the vertical scanning direction can be set more minutely based on the total amount of the image data.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 Other objects, features and advantages of the present invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic longitudinal sectional view of an image scanner of an embodiment of the

present invention;

FIG. 2 is a block diagram showing an electrical control system of the image scanner; and

FIG. 3 is a flowchart of a control sequence of a CPU shown in FIG. 2.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description will now be given, with reference to the accompanying drawings, of an embodiment of the present invention. In this embodiment, a digital image reading apparatus of the present invention is applied to an image scanner 100 that is connected for use to a host computer that is an external apparatus.

FIG. 1 is a longitudinal sectional view of the image scanner 100, and FIG. 2 is a block diagram showing an electrical control system of the image scanner 100. As shown in FIG. 1, the image scanner 100 basically includes a double-side simultaneous reading unit 3 including a one-side reading unit 1 which can freely select a document fixing mode or a document conveying mode, and a later-installable reverse side reading unit 2. Therefore, to a user who does not need a double-side simultaneous reading function, an image scanner with only the one-side



reading unit 1 is provided.

First, a description will be given of a structure of the one-side reading unit 1. The one-side reading unit 1 includes a contact glass 4 on which a document sheet (not shown) is placed, and a first running body 7 having a reflector 5 and illuminating lamps (xenon lamps) 6 mounted thereon. The first running body 7 is disposed so as to be freely movable in a vertical scanning direction A indicated by a double-headed arrow in FIG. 1. In the optical path of a reflected light from the first running body 7, a second running body 9 that turns back the optical path by two reflectors 8 is disposed so as to be freely movable in the vertical scanning direction A. At the end of the optical path of the reflected light from the second running body 9, a charge coupled device (CCD) 11 is disposed with an imaging lens 10 being interposed between the CCD 11 and the reflectors 8 in the optical path.

A running body motor 12 including a stepping motor is linked to the first and second running bodies 7 and 9 with pulleys or wires so that the first and second running bodies 7 and 9 are movable in the same vertical scanning direction A with a speed ratio of 2 : 1. By this movement of a reading

5                    This scanning and reading of the document  
sheet by the one-side reading unit 1 is performed  
under the setting of a book mode that is the  
document-fixing mode. However, other than the above-  
described book mode, an automatic document feeder  
10 (ADF) mode that is the document conveying mode is set  
in the image scanner 100 as a freely selectable  
operation mode. Under the setting of the ADF mode,  
with the reading unit 60 including the running bodies  
7 and 9 being disposed at a standstill reading  
15 position B that is a home position, an ADF 13  
sequentially conveys document sheets (not shown) in  
the vertical scanning direction A so that the image  
data of the document sheets is scanned and read.

The ADF 13 includes a document tray 14, a pickup roller 15, a pair of resist rollers 16, a conveying drum 17, a pair of conveying rollers 18, and a pair of ejecting rollers 19, and sequentially conveys the document sheets in the vertical scanning direction A so that the document sheets pass the standstill reading position B to be ejected onto an

ejection tray 20. The ejection tray 20 is formed on the upper surface of a document pressing plate 21, which is provided on the contact glass 4 so as to be freely opened and closed. As shown in FIG. 2, a feeding motor M1 including a stepping motor is linked to the pickup roller 15 and the resist rollers 16 by a train of gears, and a conveying motor M2 including a stepping motor is linked to the conveying drum 17, the conveying rollers 18, and the ejecting rollers 19 by a train of gears. In the ADF 13, an endorser unit 23 and an endorser platen 24 are disposed between the conveying rollers 18 and the ejecting rollers 19. The endorser unit 23 includes a printing unit (not shown) including alphanumerical stamps impregnated with ink, and a pressing solenoid 25 pressing the printing unit to the side of the endorser platen 24. A read document is stopped on the endorser unit 23 to be fixed in a pressing direction by the endorser platen 24 so that alphabetical letters and numbers can be printed on a surface of the document by the pressure of the printing unit of the endorser unit 23.

Next, a description will be given of the reverse side reading unit 2, which is a later-installable optional member. The reverse side reading unit 2 includes a contact-type image sensor

(CIS) 26 and a white roller 27, which are installed later in a reading position C set between the conveying drum 17 and the conveying rollers 18 in the path in which the document sheets are conveyed (hereinafter referred to as a conveying path). The CIS 26 reads a side of a document sheet which side is reverse to the side of the document sheet read by the CCD 11, and is disposed above the conveying path to face downward. The CIS 26 is a non-magnifying-type photoelectric transduction element integrally formed of lamps for illuminating the reverse side of the document sheet, a non-magnifying lens, and a sensor array. The white roller 27 positioned opposite to the CIS 26 across the conveying path is also used as a white member for a shading correction at the time of a reading by the CIS 26.

The image scanner 100 houses a unit board forming a later-described electrical system in its lower inside portion. Here, a description will be given, with reference to FIG. 2, of a block structure and a function of the electrical system of the image scanner 100.

In the CCD 11 provided on a sensor board unit (SBU) 31, first, a reflected light from a read document made incident on the CCD 11 is converted

into analog image data having voltage values corresponding to its light intensity. Then, the analog image data is divided into image data of reading elements positioned at the odd bits of the CCD 11 and image data of reading elements positioned at the even bits of the CCD 11 and is outputted from the CCD 11 so as to be processed with a low-frequency clock signal. In an analog processing circuit (not shown) formed on the SBU 31, a dark electric potential part of this analog signal is eliminated, the odd-bit and even-bit image data are synthesized, and a gain adjustment is performed so that the analog signal has a predetermined amplitude. Thereafter, the analog signal is inputted to an analog-to-digital (A/D) converter (not shown) to be digitized.

The digitized image data is binarized after processes such as a shading correction, a gamma control, and a modulation transfer function (MTF) correction are performed thereon by an image processing unit (IPU) 33 on a scanner control unit (SCU) 32. The binarized image data is outputted as a video signal together with a page synchronizing signal, a line synchronizing signal, and an image clock.

The video signal outputted from the IPU 33

is inputted to an option IPU 35 via a connector 34.  
The video signal inputted to the option IPU 35 is  
subjected to predetermined image processing in the  
option IPU 35, and is again inputted to the SCU 32.

5 The function of a reading means is thus realized.

The video signal inputted again to the SCU  
32 is inputted to a selector (not shown). The video  
signal outputted from the IPU 33 is also inputted to  
the selector so as to determine whether to perform  
10 the image processing in the option IPU 35. The video  
signal outputted from this selector is inputted to a  
scanner image buffer controller (SiBC) 37 controlling  
a dynamic random access memory (DRAM) 36 serving as  
image memory, and is stored in the DRAM 36 as image  
15 data. The image data stored in the DRAM 36 is  
transferred to the external host computer via, for  
instance, a SCSI controller 38 or 1394 controller 52  
provided on an IEEE (Institute of Electrical and  
Electronic Engineers) 1394 board connected to the SCU  
20 32. That is, in the digital image reading apparatus  
according to this embodiment, two kinds of general-  
purpose interfaces of IEEE 1394 and SCSI are  
selectably employed as a communication means in an  
image data transfer means for transferring the image  
25 data to the host computer. Therefore, the digital

image reading apparatus of the present invention can be connected to a large number of external devices without developing a new external device interface.

On the other hand, analog image data  
5 optical-electrical-transduced in the CIS 26 is converted into digital image data on a reverse sensor board unit (RSBU) 39 for a reverse side of a document in the ADF 13. The digitized image signal is subjected to a shading correction on the RSBU 39 to  
10 be outputted to a reverse side control unit (RCU) 40 included in a main body. The RCU 40 includes a DRAM, an SiBC controlling the DRAM, and an NIPU (not shown, respectively). The image data is temporarily stored in the DRAM to be transferred to the SCU 32. A  
15 switching between the image data transferred from the RCU 40 to the SCU 32 and the image data outputted from the SiBC 37 provided on the SCU 32 is possible so that one of the two image data is selected to be transferred to the SCSI controller 38 or the 1394  
20 controller 52. An ADF driving unit (ADU) 47 serves to relay a power supply to electric components used for the ADF 13. As shown in FIG. 2, the ADU 47, which includes a motor driver and I/O connectors, is connected to the endorser unit 23, the pressing  
25 solenoid 25, a display PCB 61, a conveying sensor 62,

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a resist sensor 63, an ejection sensor 64, a document sensor 65, an ADF lift-up sensor 66, a tray-lifting clutch 67, a feeding clutch 68, the feeding motor M1, and the conveying motor M2.

5           The ADU 47 is also connected to an input/output board (IOB) 69 including a motor driver and I/O connectors. The IOB is connected to the SBU 31, an operation panel 48, the running body motor 12, a lamp regulator 71, a cooling fan 72, an optional  
10 network operation panel (not shown), an LCD (not shown), an LED (not shown), and switches including a ten key (not shown). The running body motor 12 is connected to a motor interlock switch 70, and the lamp regulator 71 is connected to the illuminating  
15 (xenon) lamps 6. The IOB 69 is also connected to a power supply unit (PSU) 50 including an AC switch. The PSU is connected to an inlet 74.

A CPU 44 performing centralized control of each part, a ROM 45 prestoring fixed data such as a  
20 control program, and a RAM 46 serving as a work area are mounted on the SCU 32 and connected to a CPU bus 49. The CPU bus 49 is also connected to the IPU 33, the SiBC 37, and the SCSI controller 38. The CPU 44 operates to control the SCSI controller 38 or the  
25 1394 controller 52 so as to communicate with the

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external host computer.

5 The operation panel 48 used as a keyboard  
and a display is provided on the outer surface of the  
image scanner 100 to be connected to the CPU 44. An  
abort switch, a start switch, and a mode selection  
switch for switching between the document fixing mode  
and the document conveying mode are provided on the  
operation panel 48. When these switches are pressed  
down, the CPU 44 detects the operations of the  
10 switches via an input port.

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In addition, as a function performed under  
the control of the CPU 44, the image scanner 100 of  
this embodiment includes the function of an image  
parameter setting means for setting parameters with  
15 respect to the reading of a document image in the  
reading unit 60 based on communication with the  
external apparatus. The reading-related parameters  
include the number of pixels in a main (horizontal)  
scanning area, resolution (dpi) in the vertical  
20 scanning direction A, image composition (binary or  
multivalued), an image data transfer rate, a document  
size, and the number of document sheets. These  
parameters are communicated from the external host  
computer to be temporarily stored and set in the RAM  
25 46.

Further, as a function performed under the control of the CPU 44, the image scanner 100 of this embodiment includes a vertical scanning rate setting means for setting a reading rate (inch/sec) in the vertical scanning direction A (vertical scanning reading rate) to a desired value in reading a document image. More specifically, the CPU 44 controls the driving pulses of the running body motor 12, the feeding motor M1, and the conveying motor M2 to control the operation timings thereof. That is, the CPU 44 controls the rotation speeds of the running body motor 12, the feeding motor M1, and the conveying motor M2 so as to variably set the vertical scanning reading rate at a time of reading the document image.

Moreover, as a function performed under the control of the CPU 44, the image scanner 100 of this embodiment includes a computation means for computing the total image data amount of a read image from the reading-related parameters set by the image parameter setting means. Specifically, the total image data amount of the read image can be obtained by multiplying the number of pixels in the main scanning area by the image composition (1/8 in the case of binary data, and 1 in the case of multivalued data).

the resolution (dpi) in the vertical scanning direction A, and the number of vertical scanning lines. The number of vertical scanning lines can be obtained from the document size and the number of document sheets.

Next, a description will be given of a data transfer method based on SCSI employed as one of the communication means. The data transfer method based on SCSI is classified into a basic anachronous transfer and a synchronous transfer whose transfer rate is increasable according to a classification based on transfer rates. The anachronous transfer forms the basis of the transfer method, and information other than data, such as a message or a status, is transferred by the anachronous transfer. Specifically, the anachronous transfer is performed by a handshake protocol using REQ/ACK, and allows a transfer of, for instance, approximately 1.5 MB of data per second. On the other hand, the synchronous transfer is a mode usable only in a data phase. That is, the synchronous transfer is a mode whose object is a high-speed data transfer. Consent between a target and an initiator is required for the use of this synchronous transfer mode in a data transfer. This consent is made by determining two values of a

"REQ/ACK offset value" and a minimum transfer  
synchronization by exchanging messages of  
"synchronous data transfer requests". This  
synchronous transfer mode allows a high-speed  
5 transfer of, for instance, approximately 10 MB of  
data per second.

Next, a brief description will be given of  
IEEE 1394 employed as one of the communication means  
and a data transfer rate thereof. IEEE 1394-1995 is  
10 a fast serial bus standard standardized by the IEEE  
in 1995, which standard is centered on the physical  
layer (PHY) and the link layer (LINK). IEEE 1394-  
1995 is a standard for hardware and software for 100  
Mbps, 200 Mbps, and 400 Mbps data transfers, and the  
15 future establishment of a standard for 800 Mbps, 1.6  
Gbps, and 3.2 Gbps data transfers is now under  
consideration. IEEE 1394 has a characteristic  
function for plug and play, and a multimedia data  
transfer, that is, a function securing a band for  
20 transferring video or audio data to allow a real-time  
transfer (isochronous transfer). This function is  
disclosed, for instance, in Japanese Laid-Open Patent  
Applications No. 10-257119 and No. 11-17855.

The data transfer method of IEEE 1394 is  
25 categorized in the isochronous transfer and the

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asynchronous transfer. The isochronous transfer has an advantage that its data transfer rate is assured. Specifically, the isochronous transfer can transfer at least one packet for every 125  $\mu$ sec per channel, set talkers and listeners of up to 64 channels per node, and determine the maximum packet size for each of the data transfer rates of 100, 200, and 400 Mbps. On the other hand, the asynchronous transfer can be performed only after every isochronous transfer is completed. That is, while the isochronous transfer has the concept of channel and is somewhat similar to the broadcast that defines a talker and a listener, the asynchronous transfer is a transfer from point to point. Every transaction has the IDs of a sender and a recipient related thereto.

Next, a comparison will be made between the data transfer rates of SCSI and IEEE 1394. The data transfer rate of SCSI is 5 MB per second in the case of the asynchronous transfer and 10 MB per second in the case of synchronous transfer. The data transfer rate of IEEE 1394 is 100, 200, or 400 Mbps.

Therefore, it is concluded that SCSI has the image data transfer rate lower than that of IEEE 1394.

That is, under the conditions of the same resolution and the same reading area, the number of intermittent

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operations with suspensions is decreased to allow a stable, high-quality image reading by setting the vertical scanning reading rate to be low by the CPU 44 in the case of employing SCSI as the communication means. In setting the vertical scanning reading rate, in order to detect the image data transfer rate, a synchronization data transfer request message is employed in the case of SCSI, and transfer rate information in a packet is employed in the case of IEEE 1394.

Further, according to this embodiment, in a reading operation of reading a document image and sequentially transferring the image data of the read image to the external apparatus, the CPU 44 serves to control the vertical scanning rate setting means based on the total image data amount of the read image computed by the computation means so as to set the vertical scanning reading rate.

More particularly, in the document image reading operation that the CPU 44 is caused to perform by the control program stored in the ROM 45 under the setting of the book mode that is the document fixing mode, as previously described, the CPU 44 controls the running body motor 12 for moving the first and second running bodies 7 and 9 via the

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smaller than the storage capacity of the DRAM 36 as  
in the above-described case, the DRAM 36 is prevented  
from being filled up with the image data. Therefore,  
the running body motor 12 is free of speed control  
5 operations of gradually increasing and decreasing the  
speed thereof, thus preventing deterioration of the  
image quality. Accordingly, if the total image data  
amount of the read image is smaller than the storage  
capacity of the DRAM 36 in a reading operation  
10 expecting a large data transfer amount of image data,  
such as a color or multivalue reading operation, a  
reading time can be shortened and thus the  
performance of the apparatus can be improved since  
the vertical scanning reading rate can be set to a  
15 value higher than that set based on the total image  
data amount of the read image.

The description has been given above of the  
reading operation of a document image performed by  
the CPU 44 under the setting of the book mode that is  
20 the document fixing mode. However, the present  
invention is not limited to this, but is also  
applicable under the setting of the ADF mode that is  
the document conveying mode. In this case, the CPU  
44 controls the feeding motor M1 and the conveying  
25 motor M2 sequentially conveying the document sheets



in the vertical scanning direction A with respect to the reading unit 60, which includes the running bodies 7 and 9, and is fixedly disposed in the standstill reading position B that is the home position.

FIG. 3 is a flowchart of the above-described control sequence.

When the control sequence shown in FIG. 3 is started, the CPU 44 obtains the reading-related parameters from the external host computer in step S11. The parameters obtained in step S11 are the number of pixels in the main scanning area, the number of vertical scanning lines, the resolution, and the image composition. Next, in step S12, the CPU 44 determines whether the image composition is in binary black-and-white, in multivalue black-and-white, or in full color.

If the image composition is in binary black-and-white, in step S13, the CPU 44 computes the total image data amount from the following formula.

$$DA = PN \div 8 \times LN,$$

wherein DA is the total image data amount, PN is the number of pixels in the main scanning area, and LN is

the number of vertical scanning lines. These abbreviations are common to the following formulas.

If the image composition is in multivalue black-and-white, in step S14, the CPU 44 computes the  
5 total image data amount from the following formula.

$$DA = PN \times LN$$

If the image composition is in full color,  
10 in step S15, the CPU 44 computes the total image data amount from the following formula.

$$DA = PN \times 3 \times LN$$

15 After thus computing the total image data amount, in step S16, the CPU 44 compares the storage capacity of the DRAM 36 with the total image data amount. Here, the storage capacity of the DRAM 36 means its storage capacity available at a time of  
20 performing step S16. If the storage capacity of the DRAM 36 is equal to or larger than the total image data amount, in step S18, the CPU 44 set the vertical scanning reading rate to the highest value. If the  
25 value, a scanning operation can be performed in the

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shortest period. However, the vertical scanning reading rate does not always have to be set to the highest value. The reading time can be shortened by setting the vertical scanning reading rate to a value higher than a value to which the vertical scanning reading rate is currently set. On the other hand, if it is determined in step S16 that the storage capacity of the DRAM 36 is smaller than the total image data amount, in step S17, the CPU 44 computes the vertical scanning reading rate by using the following formula.

$$VR = LN \div RE \times 25.4 \div (DA \div I/F TR),$$

wherein VR is the vertical scanning reading rate, RE is the resolution, I/F TR is the data transfer rate of the interface such as SCSI or IEEE 1394 employed to transfer the read data from the DRAM 36 to the external apparatus, and 25.4 means that one inch corresponds to 25.4 mm.

In step S19, the CPU 44 computes the pulse rate of the driving pulses that drive the running body motor 12 including the stepping motor, or the feeding and conveying motors M1 and M2 each including the stepping motor. The pulse rate is a reading time

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per pulse and is obtained by dividing a moving distance per pulse of the reading unit 60 or a document sheet by the vertical scanning reading rate.

5 The description of the embodiment of the present invention has been given above. The digital image reading apparatus according to the present invention includes, in addition to an image scanner, a digital copying machine or a facsimile machine with a function of transferring data to an external  
10 apparatus.

The present invention is not limited to the specifically disclosed embodiment, but variations and modifications can be made without departing from the scope of the present invention.

15 The present invention is based on Japanese priority applications No. 2000-036010 filed on February 15, 2000, and No. 2001-32693 filed on February 8, 2001, the entire contents of which are hereby incorporated by reference.

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